

The paragraph beginning at page 1, line 23, is amended as follows:

Heat sinks have been used to assist in dissipating heat from the processor and other heat-producing [heat producing] components within a housing. However, the overall size of the heat sink is limited by the volume constraints [constrains] of the housing, and the footprint and/or the size constraints. Heat dissipation has been increased by using fasteners such as mechanical clips, epoxy, [and/or] glue, and/or rivets which physically hold a heat sink to the processor package mounted on a printed circuit board. For some heat sinks, spring-loaded fasteners are used to couple the heat sink with the heat-producing [heat producing] components to enhance [the] heat dissipation [dissipated] from the heat-producing [heat producing] components. However, such fasteners require one or more additional final assembly process steps, which results in requiring additional manufacturing resources after all of the soldering steps are completed. These additional manufacturing steps increase the cost of providing a thermal solution to heat-producing [heat producing] components such as chipsets.

The paragraph beginning at page 2, line 5, is amended as follows:

Figures 1, 2, 3, and 4 illustrate conventional manners 100, 200, 300, and 400, respectively, of coupling the heat sink to heat-producing [heat producing] components such as chipsets and/or microprocessors. Figure 1 illustrates using a mechanical clip 110 to couple [the] heat sink 120 to heat-producing [the heat producing] component 130 mounted on a printed circuit board 140 to enhance heat dissipation from the heat-producing [heat producing] component 130. Figure 2 illustrates using epoxy and/or glue 210 to couple [the] heat sink 120 to heat-producing [the heat producing] component 130. Figure 3 illustrates using spring-loaded fastener 310 to couple [the] heat sink 120 to heat-producing [the heat producing] component 130. Figure 4 illustrates using rivets 410 to couple [the] heat sink 120 to heat-producing [the heat producing] component 130. All of these prior art techniques require one or more additional final assembly process steps, which increases the cost of providing a thermal solution to heat-producing [heat producing] components. In addition, the prior art techniques illustrated in Figures 1, 3, and, 4 require substantial circuit board space to mechanically retain the heat sink in place [in-place].

The paragraph beginning at page 2, line 18, is amended as follows:

For the reasons stated above, and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the present specification, there is a need in the art for a low-cost technique that consumes substantially less circuit board space than [that] the prior art techniques to provide a low-cost thermal solution to the heat-producing [heat producing] components.

The paragraph beginning at page 2, line 25, is amended as follows:

Figures 1, 2, 3, and 4 illustrate prior art techniques of coupling heat sinks to heat-producing [heat producing] components mounted on a printed circuit board.

The paragraph beginning at page 2, line 27, is amended as follows:

Figures 5, 6, 7, and 8 illustrate perspective [front elevational] views of different example embodiments of [the] heat sinks according to the embodiments of the present invention.

The paragraph beginning at page 3, line 1, is amended as follows:

Figures 9, 10, 11, and 12 illustrate a [the] process [steps] for assembling an electronic assembly [device] using the heat sinks shown in Figures 5, 6, 7, and 8 according to an embodiment [the teachings] of the present invention.

The paragraph beginning at page 3, line 4, is amended as follows:

Figures 13, 14, and [ ] 15 illustrate an exemplary [the assembled] electronic assembly [device using] formed from the process [steps] shown in Figures 9, 10, 11, and 12.

The paragraph beginning at page 3, line 6, is amended as follows:

Figures 16 and 17 illustrate the coverage/wetting of a [the] thermal interface material between a [the] heat sink and a heat-producing [the heat producing] component after passing through [the] wave soldering pre-heaters.

The paragraph beginning at page 3, line 11, is amended as follows:

In the following detailed description of the embodiments, reference is made to the accompanying drawings that illustrate embodiments of the present invention and its practice. In the drawings, like numerals describe substantially similar components throughout the several views. These embodiments are described in sufficient detail to enable those skilled in the art to practice them [the invention]. Other embodiments may be utilized, and structural, logical, and electrical changes may be made without departing from the scope of the present disclosure [invention]. Moreover, it is to be understood that the various embodiments of the invention, although different, are not necessarily mutually exclusive. For example, a particular feature, structure, or characteristic described in one embodiment may be included in other embodiments. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of embodiments of the present invention are [is] defined only by the appended claims, along with the full scope of equivalents to which such claims are entitled.

The paragraph beginning at page 3, line 24, is amended as follows:

This document describes, among other things, a low-cost technique that consumes less circuit board space than [the] traditional means for providing a [the] chipset thermal solution.

The paragraph beginning at page 3, line 27, is amended as follows:

Figures 5, 6, 7, and 8 illustrate perspective [front elevational] views of different example embodiments of [the] heat sinks 500, 600, 700, and 800, respectively, according to embodiments of the present invention. Figure 5 illustrates a perspective [an isometric] view of one example embodiment of a heat sink 500 [according to the present invention]. As shown in Figure 5, [the] heat sink 500 includes two mounting pins 510[,] and a thermally conductive plate 520. In some embodiments, [the] heat sink 500 can include at least one mounting pin. The mounting pins 510 are adapted to be disposed through corresponding mounting holes in a substrate (not shown) such that when [the] heat sink 500 is thermally coupled to a heat-producing [heat producing] component (not shown), the mounting pins 510 are disposed through the holes for soldering the

mounting pins 510 in the holes for mechanically attaching the heat sink 500 to a substrate during pre-assembly operation to provide a low-cost thermal solution. In some embodiments, the heat sink 500 can include multiple mounting pins and corresponding multiple mounting holes in the substrate.

The paragraph beginning at page 4, line 9, is amended as follows:

In some embodiments, the mounting pins extend beyond the thermally conductive plate 520 such that the mounting pins 510 can be soldered when the thermally conductive plate 520 is thermally coupled to a heat-producing [heat producing] component. The heat sink 500 can be made from materials such as copper, aluminum, and other such materials suitable for dissipating the heat from a heat-producing [the heat producing] component. In some embodiments, the mounting pins 510 can be soldered to the substrate using processes such as wave soldering, surface mount soldering, and other such soldering processes. In some embodiments, mounting pins can comprise two [2] or more wave solderable pins.

The paragraph beginning at page 4, line 17, is amended as follows:

Figure 6 illustrates a perspective [an isometric] view of another example embodiment of a heat sink 600 according to the present subject matter [invention]. The heat sink 600 shown in Figure 6 is similar to [the] heat sink 500 shown in Figure 5 except that [the] heat sink 600 shown in Figure 6 further includes a heat exchange portion 610 disposed across from the mounting pins 510. In some embodiments, the heat exchange portion 610 includes multiple fins that extend upwardly [upward] beyond the thermally conductive plate 520.

The paragraph beginning at page 4, line 23, is amended as follows:

Figures 7 and 8 illustrate perspective isometric views of other example embodiments of heat sinks 700 and 800, respectively, according to the present subject matter [invention]. The heat sinks 700 and 800 are similar to [the] heat sinks 500 and 600 shown [respectively] in Figures 5 and 6, respectively, except that [the] heat sinks 700 and 800 include four mounting [4] pins instead of the two mounting [2] pins shown in Figures 5 and 6. Also, the thermally conductive

plate 710 is configured to include the four mounting [4 ]pins as shown in Figures 7 and 8.

The paragraph beginning at page 4, line 29, is amended as follows:

Figures 9, 10, 11, and 12 illustrate one example embodiment of process actions 900, 1000, 1110, and 1210, respectively, for attaching at least one heat-producing component 130 mounted on a printed circuit board 140 to a heat sink such as heat sink 600 shown in Figure 6 [methods 900, 1000, 1110, and 1210, respectively required for assembling an electronic device using the heat sinks shown in Figures 5, 6, 7, and 8 to at least one heat producing component 130 mounted on a printed circuit board 140 according to the teachings of the present invention].

The paragraph beginning at page 5, line 4, is amended as follows:

Action [Method] 900, as shown in Figure 9, begins with mounting a front side 930 of the heat-producing [heat producing] component 130 to the [substrate] printed circuit board (also referred to as a “substrate” herein) 140. The substrate 140 also includes multiple holes 950. In some embodiments, mounting the heat-producing [heat producing] component 130 includes electrically and/or mechanically coupling the component 130 to the substrate 140. The heat-producing [heat producing] component 130 includes integrated circuit devices such as a chipset, a microprocessor, a digital signal processor, and/or an application-specific integrated circuit device.

The paragraph beginning at page 5, line 11, is amended as follows:

In addition, action [Method] 900 as shown in Figure 9 also includes positioning a layer of thermal interface material 910 onto [on to] a back side 940 of the heat-producing [heat producing] component 130. The back side 940 of the heat-producing [heat producing] component 130 is disposed across from the front side 930. In some embodiments, [the] thermal interface material 910 is either a phase change thermal interface material, such as Chomerics T725, Chomerics 705, Chomerics 710, and/or Chomerics 454, or a thermal grease such as Thermalloy TC1, Shinetsu G749, and/or Shinetsu G750. While the thermal greases, such as Shinetsu G749[, ]and Shinetsu G750, are in liquid (viscous) [(viscus)] form at room temperature,

the phase change thermal [material] materials, such as Chomerics T725, Chomerics 705, Chomerics 710, and Chomerics 454, are in a soft solid paste form at room temperature that melts with heating. These thermal interface materials melt [when the active device such as the heat sink it is mounted on is heated at the] at typical wave-soldering temperatures. Generally, the phase transition (changing from a paste-like [paste like] state to a liquid state) temperatures of these phase change thermal interface materials are around 55<sup>0</sup>C - 65<sup>0</sup>C. Typically the ambient temperatures inside [the] wave soldering machines (around the pre-heaters and the solder wave chambers) are well above 70<sup>0</sup>C. Temperatures above 70<sup>0</sup>C are generally sufficient to melt the above-mentioned phase change thermal interface materials. Action [Method] 900 is compatible with use of either of the above-mentioned thermal interface materials.

The paragraph beginning at page 5, line 29, is amended as follows:

Action [Method] 900, as shown in Figure 9, further includes aligning [a] heat sink 600 including at least one mounting pin 510 over the thermal interface material 910 and further through the corresponding at least one hole 950 in the substrate 140 so that the mounting pins 510 can be wave-soldered [wave soldered] to the substrate 140. It can also be envisioned that the mounting pins 510 can be designed to be soldered to the substrate 140 using other circuit board assembly techniques, such as pin-in-paste, surface mount, and other methods suitable for attaching the heat sink 600 to the heat-producing [heat producing] component 130 during pre-assembly operations.

The paragraph beginning at page 6, line 7, is amended as follows:

In some embodiments (refer to Figures 5 and 6), the heat sink 600 is formed to include a thermally conductive plate 520 such that the mounting pins 510 extend beyond the thermally conductive plate 520. In some embodiments, the heat sink 600 is formed to further include a heat exchange portion 610 (refer to Figure 6), which extends outwardly from [beyond] the plate 520. The heat exchange portion 610 is formed such that the heat exchange portion 610 is disposed across from (i.e. on an opposite side from) the heat-producing [heat producing] component. In some embodiments, forming the heat exchange portion 610 includes forming multiple fins that

extend away from the thermally conductive plate 520. The heat sink 600 is made from materials such as copper, aluminum, and other such materials suitable for dissipating heat away from the heat source.

The paragraph beginning at page 6, line 16, is amended as follows:

Action [Method] 1000, as shown in Figure 10, includes reducing the viscosity of the thermal interface material 910 by preheating 1010 the thermal interface material 910 in a wave soldering pre-heater [preheater] to cause the thermal interface material 910 to wet the heat-producing component 130 to thermally couple the heat sink 600 to the heat-producing [heat producing] component 130. In some embodiments, [the] reducing the viscosity of the thermal interface material 910 further includes loading the substrate 140, including the heat-producing [heat producing] component 130, thermal interface material 910, and the heat sink 600 onto [on to] a conveyor of a wave soldering machine (not shown) and reducing the viscosity of the thermal interface material 910 by preheating (represented by wavy arrows 1010) [1010] the thermal interface material 910 disposed between the back side 940 of the heat-producing [heat producing] component 130 and the heat sink 600 such that the thermal interface material 910 melts and wets sufficiently the back side 940 and the heat sink 600 to provide sufficient thermal coupling between the heat-producing [heat producing] component 130 and the heat sink 600. In a typical wave soldering machine, the thermal interface material 910 will be [is] exposed to temperatures of more than 70°C for a period of 15 to 25 seconds over the pre-heaters, and further the thermal interface material 910 is exposed to temperatures above 80°C for a period of 8-12 seconds when passing over a [the] solder wave in the wave soldering machine. This is generally sufficient to melt the thermal interface material 910 and wet the back side 940 and the heat sink 600 to produce the necessary thermal coupling between the heat-producing [heat producing] component 130 and the heat sink 600. The above-mentioned exposure times and temperatures can be easily changed/adjusted in a typical wave-soldering machine to suit the requirements of a particular process.

The paragraph beginning at page 7, line 7, is amended as follows:

Action [Method] 1110, as shown in Figure 11, includes attaching the heat sink 600 in a fixed position onto [on to] the heat-producing [heat producing] component 130 and the substrate 140 by soldering the at least one mounting pin 510 to the substrate 140 while the thermal interface material 910 is still hot. In some embodiments, [the] attaching the heat sink 600 in a fixed position includes placing the heat sink 600 in a fixed position onto [on to] the heat-producing [heat producing] component 130 and the substrate 140 by soldering the at least one mounting pin 510 to the substrate 140 to form solder joints 1120. Soldering the mounting pins 510 locks in the thermal coupling established by the wetting of the thermal grease 910 during the preheating to provide a low-cost thermal solution to the heat-producing [heat producing] component 130. In some embodiments, soldering the mounting pins 520 onto the substrate includes wave soldering the at least one mounting pin 510 to the substrate 140 to mechanically attach the heat sink 600 to the substrate 140.

The paragraph beginning at page 7, line 19, is amended as follows:

Action [Method] 1210, as shown in Figure 12, includes cooling the soldered mounting pins 510 to mechanically [mechanical] fix the heat sink 600 in place [in-place] to form the solder joints 1120 and to further lock in [lock-in] the thermal coupling established between the back side 940 of the heat-producing [heat producing] component 130 and the heat sink 600 while the thermal interface material 910 is still hot.

The paragraph beginning at page 7, line 24, is amended as follows:

Figures 13, 14, and, 15 illustrate a top view 1300, a side elevational view 1400, and a front elevational view 1500, respectively, of an electronic assembly [device] including assembled substrate 140 [including the] and heat sink 500 thermally bonded to [the] heat-producing [heat producing] component 130 using the process described with reference to Figures 9, 10, 11, and 12. The process of coupling the heat sink 500 to the heat-producing [heat producing] component 130 according to embodiments of the present invention is described in more detail with reference to Figures 9, 10, 11, and 12. It can be envisioned that more than one heat-producing [heat

producing] component can be sandwiched between the substrate 140 and the heat sink 500 and further the heat sink 500 can be thermally bonded to more than one heat-producing [heat producing] component using the process described with reference to Figures 9, 10, 11, and 12. Although not shown in Figures 13, 14, and 15, it can be envisioned that an air movement device, such as a fan, can be mounted on the heat sink 500 to further enhance heat dissipation from the heat sink 500. In some embodiments, the heat-producing [heat producing] component 130 is an [a] integrated circuit device such as a chipset, a microprocessor, a digital signal processor, and/or an application-specific integrated circuit device.

The paragraph beginning at page 8, line 9, is amended as follows:

Figures 16 and 17 illustrate the coverage/wetting of [the] thermal interface material between a heat sink 500 and a heat-producing component 130 after passing through wave soldering pre-heaters [on the heat sink side 1600 and the heat producing component side 1700 after passing through the wave pre-heaters]. Figure 16 illustrates a view 1600 of the thermal interface material coverage 1620 on the underside of heat sink 500 after passing through the wave soldering pre-heaters [on the heat sink side 1620]. Also shown in Figure 16 in dotted line is the outline of the original thermal interface material [paste] 1610 disposed between the heat sink 500 and the heat-producing [heat producing] component 130 before passing through the wave soldering pre-heaters. Figure 17 illustrates a view 1700 of the thermal interface material [910] coverage 1710 on the top side of heat-producing component 130 after passing through the wave soldering pre-heaters [on the heat producing component 130 side 1710]. It can be seen from Figures 16 and 17 that the thermal interface material 910 (refer to Figures 9-12) has completely wet [wetted] the heat-producing [heat producing] component 130, and that the thermal interface material coverage 1620 and 1710, respectively, on the heat sink 500 (Figure 16) and on the heat-producing component 130 (Figure 17) has spread beyond the dashed outline of the originally disposed thermal interface material [paste] 1610 after passing through the wave soldering pre-heaters in a typical wave soldering machine.